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NORTH AMERICAN SPECIES OF PERIDERMIUM ON PINE[1]

JOSEPH CHARLES ARTHUR AND FRANK DUNN KERN

Nearly eight years ago the writers published an article in the *Bulletin of the Torrey Botanical Club*[2] treating of the species of *Peridermium* then known in North America. Since that time much information has accumulated to supplement what was there said and to correct some errors. That article was founded upon meager material for the most part, but all then available, yet it served an important purpose in stimulating observation and in directing attention to the less known forms.

It is now proposed to review that portion of the previous article which related to the forms of *Peridermium* occurring upon the leaves and bark of various species of pine, and to leave the remainder of the article for possible future notice. In thus restricting the work it will be feasible to show some advances that have been made in the last eight years, to discuss the difficulties encountered in limitation and identification of species, and to set forth the more conspicuous problems for the future. To do this much for the pine-inhabiting species will require as much space as can well be granted for a single article, although other genera of gymnospermous hosts bear species of *Peridermium* in equal need of similar presentation.

The first discussion of the American pine-inhabiting forms was by Underwood and Earle[3] in 1896, who ably presented the subject as known at that time. Only three species were recognized from the eastern United States: *Peridermium acicolum* and *P. orientale* both on leaves and *P. cerebrum* on bark. Two species not seen by the authors had been described from western United States: *P. filamentosum* and *P. Harknessii,* both on bark. A species from

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[1] Read before the Botanical Society of America, Atlanta meeting, December 31, 1913.

[2] Volume 33, pp. 403–438. 1906.

[3] Underwood, L. M., & Earle, F. S.: Notes on the pine-inhabiting species of *Peridermium*. Bull. Torrey Club **23**: 400–405. 1896.

Colorado, *P. Engelmanni,* was erroneously included among western forms, probably because published as on *Pinus Engelmanni,* now referred to the genus *Picea.*

The five recognized species in 1896 had expanded to fifteen species when the present authors published in 1906, seven being on leaves and eight on bark. At the present time all the seven leaf forms seem to be worthy of recognition, one additional species has been described by Long in the meantime, one species has been introduced from Europe, and two forms are to be separated in this paper, making eleven leaf forms altogether. The greatest upheaval and readjustment has taken place among the bark forms. Much reliance was necessarily placed at first on the form of the gall, but later information derived in part from cultures has given better apprehension of the species. The aecial form of the oak *Cronartium, P. cerebrum,* is now made to include the western form, *P. Harknessii,* as well as the three supposed new species of our former paper, *P. fusiforme, P. globosum,* and *P. mexicanum.* The two diverse-appearing forms, *P. filamentosum* and *P. stalactiforme,* have been united with some hesitation. The misuse of the name, *P. pyriforme,* has been rectified, and the aecial form of the currant rust, *P. Strobi,* which has been introduced from Europe since our former paper, has been added. Altogether five species of bark forms are recognized, the same as previously, but differently assorted.

So far as known, fourteen species out of the sixteen included in this paper are native to North America, and of the fourteen only two are also known outside of North America. One of these, *P. Rostrupi,* is common in Europe, and the other, *P. cerebrum,* is common in Japan.

The remaining two species have been introduced from Europe in recent years, and neither of them is yet established. One of them, *P. Strobi,* is of such economic interest that a stubborn fight is being waged against it in this country. The other one, *P. Fischeri,* is only known in one tree nursery in Wisconsin, and was first seen in 1912. It was found on *Pinus sylvestris,* being the first collection of a *Peridermium* on the leaves of this conifer to be found in North America. In the North American Flora (vol. 7, page 94) *P. oblongisporium,* which also occurs on *Pinus* *sylvestris,* is mentioned. The occasion of the citation was the appearance of the alternate stage on *Senecio vulgaris* in Rhode Island. But the rust did not become established, and has not been reported since. The aecial form has never been seen in this country.

The three main sources of information which have led to a better understanding of the forms of *Peridermium* on pine are increased collections with field observations, culture work, and microscopic comparison.

The collections in herbaria are remarkably few and imperfect, due doubtless to two main reasons. These forms of rust appear early in the season when not many collectors of rusts are in the field, and consequently even when abundant they are only incidentally represented in sets of specimens. The bark forms for the most part produce large galls, sometimes a foot or more in diameter, and almost invariably cumbrous and troublesome in comparison with most rust specimens. In consequence only a small fragment of the original gall as a rule is taken, and often with scant data. Specimens in the best condition to study must generally be placed in boxes, as fruits and woody fungi are, rather than in mycological packets. Field observations relative to the probable alternate forms are meagre and principally by a few observers in recent years.

Culture work is not so simple and expeditious as with most other groups of rusts. The information obtained in this way is invaluable, and it will never be possible to have definite knowledge of the species until many more cultures are made, than are at present available. Up to the present writing the following is the record of cultures made in North America with the several forms of *Peridermium* on pine, both foliicolous and caulicolous.

Cultures in the field may result in valuable information, and can afterward be substantiated under glass, if necessary. Damp cool weather is most favorable for the work. Sowings from teliosporic material of *Coleosporium* may be made by suspending fresh material over growing pines, more conveniently over low or seedling pines, care being taken that such material does not wilt for some hours, and that the pine leaves have a moist surface, at least during one night. In the case of *Cronartium* the germinat-

RECORD OF THE CULTURES PROVING RELATIONSHIPS BETWEEN THE SPECIES OF PERIDERMIUM AND THEIR ALTERNATE PHASES

Year	Species of *Peridermium* Host of Culture Material	Trial Host Species of *Cronartium* or *Coleosporium*	Investigator Place of Publication
1902	*Per. cerebrum* *Pinus virginiana*	*Quercus coccinea* *Cron. Quercus*	Shear, Jour. Myc. **12**: 89–92. 1906.
1904	*Per. Rostrupi* *Pinus rigida*	*Campanula americana* *Col. Campanulae*	Kellerman, Jour. Myc. **11**: 32. 1905.
1906	*Per. acicolum* *Pinus rigida*	*Solidago rugosa* *Col. Solidaginis*	Clinton, Rep. Conn. Exp. Sta. for **1906**: 320. 1907.
1907	*Per. cerebrum* *Pinus virginiana*	*Quercus velutina* *Cron. Quercus*	Arthur, Jour. Myc. **13**: 194. 1907.
1907	*Per. Comptoniae* (*"pyriforme"*) *Pinus sylvestris*	*Comptonia asplenifolia* *Cron. Comptoniae*	Clinton, Rep. Conn. Exp. Sta. for **1097**: 380–383. 1908.
1910	*Per. carneum* *Pinus Taeda*	*Vernonia crinita* *Col. Vernoniae*	Arthur, Mycologia **4**: 29. 1912.
1912	*Per. filamentosum* (*"stalactiforme"*) *Pinus contorta*	*Castilleja miniata* *Cron. coleosporioides*	Meinecke; Hedgcock, Phytopath. **2**: 176. 1912 (further details in letter from Meinecke); also Meinecke, Phytopath. **3**: 167. 1913.
1912	*Per. filamentosum* *Pinus* [*scopulorum*]	*Castilleja* sp. *Cron. coleosporioides* (*"filamentosum"*)	Hedgcock, Phytopath. **2**: 176–7. 1912.
1912	*Per. Comptoniae* *Pinus sylvestris, P. ponderosa*	*Comptonia asplenifolia* *Cron. Comptoniae*	Spaulding, Phytopath. **3**: 62. 1913.
1913	*Per. cerebrum* (*"fusiforme"*) *Pinus Taeda*	*Quercus rubra, Q. Phellos* *Cron. Quercus*	Arthur & Kern, here reported.
1913	*Per. inconspicuum* *Pinus virginiana*	*Coreopsis verticillata* *Col. inconspicuum*	Hedgcock and Long, Phytopath. **3**: 250. 1913.
1913	*Per. delicatulum* *Pinus rigida*	*Euthamia graminifolia* *Col. delicatulum*	Hedgcock and Long, Phytopath. **3**: 250. 1913.
1913	*Per. Comptoniae* *Pinus ponderosa*	*Comptonia asplenifolia* *Cron. Comptoniae*	Hedgcock; Spaulding in Phytopath. **3**: 308. 1913.
1913	*Per. Comptoniae* *Pinus ponderosa, P. sylvestris, P. Taeda, P. austriaca*	*Comptonia asplenifolia* *Cron. Comptoniae*	Spaulding, Phytopath. **3**: 308, 309. 1913.

ing teliospores are inserted into a slit in the bark of the pine, care being taken to include as little debris as possible and to keep the surface moist for some hours.

The basidiospores both in *Coleosporium* and *Cronartium* are ready to be shed immediately upon maturity of the telia, which is largely from July to late fall. The earlier maturing telia are likely to give best results. Some indications of success may occasionally be seen after a few weeks, but the aecia are not likely to appear until the following spring.

Reverse cultures may similarly be made by suspending leaves or bark of pine, bearing the aecia, over the suspected alternate host, usually low growing herbs. Such work must largely be done in spring; and the first mature aecia from such cultures may be again used, and provide more viable spores than those gathered in the field. The uredinia that result from aecial infection will probably appear within ten to thirty days, usually on the under side of the leaves.

Herbarium specimens should invariably be saved, both of the material from which sowings are made, and of the resulting spore forms.

In the present stage of knowledge there is needed a large amount of work on the microscopic characters of the collections now in herbaria. It not infrequently happens that two collections having similar gross appearance present well marked microscopic differences. Or it may be that two specimens with dissimilar gross appearance, as *P. cerebrum* and *P. fusiforme,* now known to be one species, have no material microscopic differences, when well studied. A certain amount of variation in all the microscopic characters must be expected, in some species more than in others. The extent of this variation in each species can only be ascertained by extended microscopic study of large numbers of authenticated collections made at different times and places. Although more characters are now utilized than formerly, especially those pertaining to the peridium, and better technique employed, yet it is not likely that all species can be definitely separated by microscopic characters alone. Especially among those species of *Peridermium* which are aecial forms of *Coleosporium,* that is, the foliicolous forms, there is frequently great similarity. But even in such cases, careful microscopic diagnoses must be held important.

KEY TO THE FOLIICOLOUS SPECIES OF PERIDERMIUM ON PINUS, ALL BEING THE AECIAL STAGE OF SPECIES OF COLEOSPORIUM

Peridia low, fragile, and inconspicuous.	
Peridial cells quadrilateral in face view, 20–29 μ long.	1. *P. delicatulum.*
Peridial cells oblong in face view, 38–55 μ long.	2. *P. inconspicuum.*
Peridia medium-sized, mostly 0.5–1.2 mm. high.	
Peridial cells slightly overlapping, the side walls 3–4 μ thick or less.	
Spores broadly ellipsoid, the wall 2 μ or less thick.	3. *P. Fischeri.*
Spores narrowly oblong, the wall 2 μ or more thick.	4. *P. montanum.*
Peridial cells strongly overlapping, the side walls 5–9 μ thick.	
Spores moderately and uniformly verrucose, the wall uniformly thick.	5. *P. californicum.*
Spores closely verrucose, sometimes with a smooth area, the wall varying in thickness.	6. *P. acicolum.*
Peridia large and firm, mostly 0.7–1.5 mm. high, occasionally up to 2.5 mm.	
Peridial cells rather finely verrucose, spores verrucose with large deciduous papillae.	7. *P. gracile.*
Peridial cells rather coarsely verrucose.	
Peridial cells with side walls moderately thick (4–7 μ).	
Spores evenly and moderately verrucose.	8. *P. intermedium.*
Spores densely verrucose with prominent elongate papillae.	9. *P. Rostrupi.*
Peridial cells with side walls very thick (7–12 μ).	
Spores with walls moderately thick (2.5–3.5 μ).	10. *P. guatemalense.*
Spores with walls thick (3.5–5.5 μ).	11. *P. carneum.*

1. PERIDERMIUM DELICATULUM Arth. & Kern, Bull. Torrey Club 33: 412. 1906

O. Pycnia 0.3–0.4 mm. broad by 0.5–1 mm. long, low-conoidal, 80–100 μ high.

I. Aecia erumpent from longitudinal slits 1–5 mm. long, delicate, scarcely protruding above the ruptured epidermis; peridial cells usually quadrilateral or hexagonal in face view, 16–24 x 20–29 μ, not or only slightly overlapping, the side walls 2–3 μ thick, the inner wall finely and closely verrucose with uniform papillae;

aeciospores ovoid or cuboidal, 19–21 x 21–28 μ, the wall 1.5–2 μ, finely and evenly verrucose.

On *Pinus rigida* Mill., Connecticut (*Clinton*), Maryland (*Hedgcock* & *Long,* see Mycologia 4: 282. 1912), Massachusetts (*E. T. Bartholomew* in Barth. N. Am. Ured. *720*).

On *Pinus* sp., Florida (Holway in Barth. N. Am. Ured. *517*).

Type collected at St. Augustine, Florida, on *Pinus* sp. (doubtfully *P. Taeda*) March 27, 1903, *E. W. D. Holway.*

DISTRIBUTION: Atlantic coast from Massachusetts to Florida. The telial collections range from Maine to Kansas southward to West Virginia and Texas, but have not been found in the southeastern part of the United States.

This species stands apart from the other foliicolous species on pine on account of the short, fragile peridium and the small, quadrilateral peridial cells. *Per. inconspicuum,* since described by Long, has a peridium which resembles this species in being rather short and delicate, but differs in having larger, thicker-walled peridial cells of an oblong shape. The range for the species has been extended northward along the Atlantic coast as far as Massachusetts, but when careful search is made for it, the range will doubtless be found much greater.

Clinton (Rep. Conn. Exp. Sta. for 1912, p. 353) made observations in the field which led him to think that the telial stage of this form occurs on *Euthamia,* and recently confirmatory cultures have been reported by Hedgcock and Long (Phytopath. 3: 250. 1913). The species apparently has distinctive microscopic characters, and is to be called *Coleosporium delicatulum* (Arth. & Kern) Hedg. & Long, Phytopath. *l. c.*

2. PERIDERMIUM INCONSPICUUM Long, Mycologia 4: 283. 1912

O. Pycnia 0.2–0.3 mm. broad by 0.3–0.7 mm. long, low-conoidal, 85–120 μ high.

I. Aecia flattened laterally, 0.3–0.7 mm. long, by 0.3–0.8 mm. high; peridial cells oblong in face view, 19–27 x 38–55 μ, overlapping, the side walls 3–4 μ thick, the inner wall rather finely and closely verrucose with uniform papillae; aeciospores ellipsoid, 16–18 x 22–30 μ, the wall 1.5–2 μ, finely and very closely verrucose.

On *Pinus virginiana* Mill., Maryland (*Charles; Long,* June 16, 1912).

Type collected at Glen Echo, Maryland, on *Pinus virginiana,* May 5, 1907, *Miss V. K. Charles.*

DISTRIBUTION: Atlantic coast in vicinity of type locality. The telial stage is known only from about the same region.

The species resembles *Per. delicatulum* somewhat in gross appearance and in the microscopic anatomy of the spores, but differs, as pointed out in a foregoing paragraph, in the character of the peridial cells. The alternate stage has been established by cultures reported by Hedgcock and Long (Phytopath. **3**: 250. 1913), and occurs on *Coreopsis.* At present it is known on *C. verticillata* and *C. major.* It is now separated from *Coleosporium Helianthi,* with which it was included in the North American Flora (**7**: 93. 1907), under the name *Coleosporium inconspicuum* (Long) Hedg. & Long.

3. PERIDERMIUM FISCHERI Kleb., Zeitschr. Pf.-Kr. **5**: 71. 1895

O. Pycnia not seen.

I. Aecia flattened laterally, 0.5–1.5 mm. long, 0.5 mm. high; peridial cells in face view broadly ellipsoid, slightly overlapping, the inner wall finely verrucose, the outer wall merely punctate; aeciospores broadly ellipsoid, more or less angular, 18–25 x 25–32 μ, the wall thin, up to 2 μ, closely and moderately verrucose.

On *Pinus sylvestris* L., "Evergreen Nursery," Sturgeon Bay, Wisconsin (*Davis,* June 25, 1913).

Type collected in Europe. (The type collection has not been seen, and the data in hand do not enable us to give details.)

In December, 1912, Dr. J. J. Davis transmitted to the junior author a specimen of *Coleosporium* from J. G. Sanders, which was collected by him in a nursery at Sturgeon Bay, Wis., on Sept. 19, 1912. This proved to be *Coleosporium Sonchi-arvensis* (Pers.) Lev., on *Sonchus asper,* and the first collection of the rust for North America.

In June, 1913, Dr. Davis visited the locality where the *Coleosporium* occurred and found aecia "in profusion on *Pinus sylvestris,*" as he wrote in a letter. Material of this collection has been carefully studied, and although it does not agree exactly with the descriptions given by European students, it is here listed, and with some confidence, as no other collection on the leaves of the

Scotch pine has been reported from North America, and as this one was found where telia of the species had been collected. Two other scanty collections were made in the vicinity both on pine seedlings, thought to be *Pinus Banksiana,* which resemble the *Peridermium* on *Pinus sylvestris,* but they are not included for want of sufficient collateral evidence. The history of this discovery is related by Dr. Davis in a recent number of Phytopathology (3: 306. Dec., 1913).

4. PERIDERMIUM MONTANUM Arth. & Kern, Bull. Torrey Club 33: 413. 1906

O. Pycnia 0.3–0.5 mm. broad by 0.5–1 mm. long, low-conoidal, 55–65 μ high.

I. Aecia flattened laterally, 1–1.5 mm. long by 0.5–1 mm. high; peridial cells ovoid to ellipsoid in face view, 23–35 x 45–65 μ, often acutish at one or both ends, slightly overlapping and easily separating, the side walls 3–4 μ thick, the inner wall rather finely verrucose with low papillae of irregular outline; aeciospores oblong to linear-oblong, 16–24 x 32–45 μ, the wall 2–3 μ, closely and rather coarsely verrucose.

On *Pinus Murrayana* Oreg. Com., Montana (*Blankinship, Stuart*); Washington (*Suksdorf 302 & 645*); Alberta (*Holway*); Rocky Mountains, Canada? (*Macoun*).

On *Pinus scopulorum* (Engelm.) Lemm., Montana (*Kelsey*).

Type collected at Rimini, Montana, on *Pinus scopulorum,* June 24, 1889, *F. D. Kelsey.*

DISTRIBUTION: The far northwest, from central Montana westward and northward.

The standing of this species remains unchanged, since its publication. One or two observers have reported finding *Coleosporium Solidaginis* in close proximity to it and have suggested a possible relation but since the specimens referred here differ very materially in microscopic characters from *Per. acicolum* of the eastern states, which is now known to belong to *Coleosporium Solidaginis,* the species is still maintained. A more likely connection would be with *Coleosporium arnicale,* which may possibly occur on more than one species of *Arnica* from the region indicated above.

5. **Peridermium californicum** sp. nov.

O. Pycnia 0.4–0.7 mm. broad by 0.5–1 mm. long, low-conoidal, about 90 μ high.

I. Aecia tongue-shape, 0.7–1.5 mm. long by 0.8–1.2 mm. high; peridial cells ellipsoid in face view, usually rounded at both ends, overlapping, 29–35 x 50–87 μ, the side walls 5–7 μ thick, the inner walls rather coarsely and closely verrucose with slightly irregular papillae; aeciospores broadly ellipsoid, 25–29 x 40–45 μ, the wall 3–4.5 μ, moderately and rather coarsely verrucose.

On *Pinus radiata* Don. (*P. insignis* Dougl.), California (*Holway*).

Type collected at Monterey, California, on *Pinus radiata,* February, 1908, *E. W. D. Holway.*

DISTRIBUTION: Known only from the type locality on the coast of middle California.

The collection here described as a new species has been made, as the date will indicate, since the publication of our first paper. It was at first determined as *Per. montanum* but a more careful study reveals the fact that it differs very markedly in the peridial cells. In this species the peridial cells are longer, thicker-walled, more coarsely verrucose, and more overlapping than in *Per. montanum.* These distinctive morphological characters together with the fact that there are several unattached species of *Coleosporium* in the region where the collection was made seem to be sufficient to warrant its recognition as a new species.

6. PERIDERMIUM ACICOLUM Underw. & Earle, Bull. Torrey Club 23: 400. 1896

O. Pycnia 0.3–0.5 mm. broad by 0.5–0.8 mm. long, low-conoidal, 80–100 μ high.

I. Aecia flattened laterally, 0.5–1 mm. long by 0.6–1.2 mm. high; peridial cells ellipsoid to ovoid in face view, 23–27 x 40–70 μ, overlapping, the side walls 5–9 μ thick, very coarsely and prominently verrucose with closely set papillae of varying size; aeciospores ellipsoid or obovoid, 20–24 x 28–40 μ, the wall closely and coarsely verrucose, with prominent, somewhat deciduous tubercles, sometimes with a smooth spot extending up one side, varying in thickness from 3–4 μ below up to 5–6 μ in the upper part.

On *Pinus pungens* Mill., Pennsylvania (Charter Oak, June 2, 1913, *Orton & Adams*).

On *Pinus rigida* Mill., Connecticut (*Bishop; Clinton,* S. Manchester, June 6, 1906, used for successful cultures on *Solidago* by the collector; *Thom*); Delaware (*Jackson,* Seaford, June 4, 1908); Pennsylvania (*Buckhout; Orton & Adams*); Massachusetts (*E. T. Bartholomew* in Barth. N. Am. Ured. *710; Cummings & Seymour* in Seym. & Earle, Econ., Fungi *223; Underwood 2862*); New Jersey (*Pennypacker* in Ellis & Ev. N. Am. Fungi *2222, Shear*); New York (*Sirrine; Whetzel & Reddick,* Junius Swamps, May 25, 1906, *Reddick,* same locality, June 1, 1907; North Carolina (*Marr*).

Type collected at Sudbury, Massachusetts, on *Pinus rigida,* June 7, 1891, *L. M. Underwood 2862.*

DISTRIBUTION: From Massachusetts and central New York southward to central North Carolina. The telial stage is known on *Solidago Aster,* and allied genera, almost throughout North America, and eventually aecial collections are likely to be taken over a far greater range than here indicated.

The most interesting development in connection with this species is the proof of its relationship to *Coleosporium Solidaginis* furnished by Clinton's cultures. This seems to be the only foliicolous species where the spores show any tendency to a smooth area after the style of the caulicolous species. This feature is not always discernable and was probably over-emphasized in our previous description. The range is here extended to western New York and southward into North Carolina.

The repeating spores of the sporophytic stage enable the species to maintain itself in regions where pines do not occur, as they often are either produced or remain viable throughout the winter, and start infection in spring without intervention of aecia.

7. PERIDERMIUM GRACILE Arth. & Kern, Bull. Torrey Club 33: 417. 1906

O. Pycnia 190–350 μ broad by 0.5–0.75 mm. long, low-conoidal, 60–75 μ high.

I. Aecia flattened laterally, 0.5–1.5 mm. long by 1–1.8 mm. high; peridial cells broadly ellipsoid in face view, 23–29 x 30–45 μ, overlapping, the side walls 4–5 μ thick, the inner wall rather finely and closely verrucose with uniform papillae; aeciospores ellipsoid, 18–

24 x 23–39 μ, the wall 3–3.5 μ thick, closely and evenly verrucose with large deciduous tubercles.

On *Pinus filifolia* Lindley, Oaxaca (*Pringle*); Jalisco (collector unknown).

Type collected in the mountains above Oaxaca, Mexico, on *Pinus filifolia,* May 28, 1894, *C. G. Pringle.*

DISTRIBUTION: Central Mexico; only two collections known.

There is no additional information concerning this species. The name was an unfortunate selection as there was a *Peridermium gracile* of Harkness (Bull. Calif. Acad. Sci. **1**: 36. 1884) on *Sarcobatus* which has been shown by cultures to be the aecial stage of a grass rust (*Puccinia subnitens*).

8. PERIDERMIUM INTERMEDIUM Arth. & Kern, Bull. Torrey Club **33**: 416. 1906

O. Pycnia 0.3–0.4 mm. broad by 0.5–0.75 mm. long, low-conoidal, 65–80 μ high.

I. Aecia tongue-shaped, 1.5–3 mm. long by 0.8–1.5 mm. high; peridial cells broadly ellipsoid, 19–34 x 34–50 μ, overlapping, the side walls 4–7 μ thick, the inner wall rather coarsely and closely verrucose with somewhat irregular tubercles; aeciospores ellipsoid, 16–20 x 23–29 μ, the wall 2.5–3.5 μ, evenly and moderately verrucose.

On *Pinus echinata* Mill. (*P. mitis* Michx.), Arkansas (*von Schrenk*); Maryland (*Galloway*); Missouri (*Barlow 1573, Demetrio* in Rab.-Wint. Fungi Eur. *3315a*); North Carolina (*Howe, von Schrenk*).

Type collected at Perryville, Missouri, on *Pinus mitis,* May, 1883, by *C. H. Demetrio* (Rab.-Wint. Fungi Eur. *3315a*).

DISTRIBUTION: From central Missouri and Arkansas to central North Carolina.

No further data concerning the standing or telial connection of this species have come to our attention, and it is here retained in its original form. The North Carolina localities are new.

9. PERIDERMIUM ROSTRUPI Ed. Fischer, Bull. Soc. Bot. France **41**: clxxii. 1894

O. Pycnia 0.2–0.4 mm. broad by 1–2 mm. long, low-conoidal, 90–110 μ high.

I. Aecia tongue-shaped, 1–3 mm. long by 0.7–1.5 mm. high; peridial cells ellipsoid in face view, 19–30 x 35–58 µ, overlapping, the side walls 4–6 µ thick, the inner wall rather coarsely verrucose with slightly irregular and somewhat deciduous tubercles; aeciospores broadly ellipsoid or globoid, 17–22 x 22–31 µ, the wall 2–3.5 µ thick, densely verrucose with prominent elongate papillae.

On *Pinus rigida* Mill., Ohio (*Kellerman,* Sugar Grove, May 17, 1902, May 1902 in Ohio Fungi *104,* May 1903, May 30, 1904; *Werner,* Ironton, May 27, 1892); Maryland (*Norman*); New Jersey (*Martindale,* in the previous paper this specimen was erroneously listed under *Per. acicolum*); North Carolina (*von Schrenk*).

Type collected in Europe, but the original publication gives no details concerning the host, place, date, or collector's name.

DISTRIBUTION: From New Jersey and central Indiana southward to central North Carolina; also in Europe. The telial stage is known over a slightly wider range.

As stated in the previous paper culture work has been done both in Europe and North America showing the relation of this species to *Coleosporium Campanulae.* No additional work has been reported since our last paper.

10. **Peridermium guatemalense** sp. nov.

O. Pycnia 0.4–0.7 mm. broad by 0.5–1.5 mm. long, low-conoidal, 51–77 µ high.

I. Aecia flattened laterally, 1.5–4 mm. long by 1–1.5 mm. high; peridial cells ellipsoid to globoid in face view, 23–26 x 26–71 µ, overlapping, the side walls 8–10 µ thick, the inner wall moderately verrucose with somewhat irregular papillae; aeciospores ellipsoid, 19–23 x 29–35 µ, the wall 2.5–3.5 µ thick, rather coarsely verrucose with irregular tubercles.

On *Pinus filifolia* Lindley, Guatemala (*Kellerman*).

Type collected at Antigua, Depart. Sacatepequez, on *Pinus filifolia,* Feb. 13, 1905, *W. A. Kellerman 4626.*

DISTRIBUTION: Known only from the type locality in central Guatemala.

When the material first came into our hands we were inclined to call it *Per. gracile;* it was even listed in a paper on The Rusts of Guatemala (Kern, Jour. Myc. **13**: 23. 1907) as that species.

The peridial cells, however, have side walls about twice as thick as in that species, and the markings are coarser and more irregular. Inasmuch as there are a number of species of *Coleosporium* in Central America which call for the existence of *Peridermiums,* the separation of this form is made with considerable confidence.

11. PERIDERMIUM CARNEUM (Bosc) Seym. & Earle, Econ. Fungi *550*. 1899

Tubercularia carnea Bosc, Ges. Nat. Freunde Berlin Mag. **5**: 88. 1811.

Peridermium oblongisporium Ravenellii Thüm. Mitth. Forstl. Vers. Oest. **2**: 316 (20). 1880.

Peridermium Ravenelii Kleb. Ber. Deutsch. Bot. Ges. 8^2: 69. 1890.

Aecidium Ravenelii Diet. in Engler & Prantl, Pflanzenfam. $\mathbf{1}^{1**}$: 78. 1897.

Aecidium carneum Farl. Bibl. Index **1**: 25. 1905.

O. Pycnia 0.4–0.7 mm. broad by 1–1.5 mm. long, low-conoidal, 60–80 μ high.

I. Aecia flattened laterally, large, 1–6 mm. long by 1–2.5 mm. high; peridial cells broadly ellipsoid in face view, 21–39 by 38–61 μ, overlapping, the side walls 7–12 μ thick, the inner wall coarsely and rather closely verrucose with uniform papillae; aeciospores ellipsoid, 21–29 x 26–35 μ, the wall 3.5–5.5 μ thick, closely verrucose with rather large tubercles often appearing deciduous.

On *Pinus Elliotii* Engelm., Florida (*Tracy,* as on "*P. australis*"); Georgia (*O'Gara*); Mississippi (*Earle,* as on "*P. australis*"; *Tracy,* as on "*P. heterophylla*").

On *Pinus palustris* Mill. (*P. australis* Michx.), Florida (*Rolfs; Stevens; Swingle* in Barth. Fungi Columb. *3043*), Louisiana (*Hedgcock,* Forest Path. no. *344*).

On *Pinus Taeda* L., Alabama (*Arthur, Kern* & *Lloyd; Atkinson,* as on "*P. serotina*"; *Underwood* & *Earle*); *Florida* (*Burger; Burger* & *Fawcett; Fawcett; Martin,* Green Cove Springs, Crescent City in Ellis, N. Am. Fungi *1026b,* both as on "*P. australis*"; *Rau* in Rab.-Wint. Fungi Eur. *3315b,* as on "*P. australis*"; *Sturgis* in Seym. & Earle, Econ. Fungi *550* as on "*P. palustris*"; *Underwood*); Georgia (*Ravenel* in Ellis N. Am. Fungi

1026a; Underwood, Toccoa, April 19, 20, and 21, the last in Seym. & Earle, Econ. Fungi *224*); Mississippi (*Arthur* & *Stretch*); Texas (*Hedgcock,* Forest Path. no. *708*).

Type collected in South Carolina on *Pinus palustris.*

DISTRIBUTION: From central North Carolina to Florida and westward to central Texas. The telial stage on *Vernonia* is common and abundant from the Gulf of Mexico to Massachusetts, Indiana and Kansas, considerably further northward than the aecial stage has been seen.

Since the previous paper several cultures have been made which show the genetic relation between this species and *Coleosporium Vernoniae.* The first cultures were made by the senior writer in the spring of 1910 (see preceding table) with *Peridermium* specimens sent from Florida; supplementing cultures were made the following season with material collected in Mississippi (see Mycologia 4: 57. 1912); and still further cultures with Florida material were made in 1913. The range of the species has been extended northward from South Carolina into North Carolina and southwestward from Mississippi into Texas.

There are several other species of *Coleosporium* common in this range and some of them have been suspected of belonging to aecial forms very much like *Per. carneum* but no positive cultures have ever been made proving such relationships. It may be possible, however, that some of the specimens here listed may be shown later to belong elsewhere. There is a considerable variation in the size and thickness of walls of the spores in these specimens but since in the experimental work both extremes have been cultured on *Vernonia* the present disposition seems the only one at present possible.

KEY TO THE CAULICOLOUS SPECIES OF PERIDERIUM ON PINUS, ALL BEING THE AECIAL STAGE OF SPECIES OF CRONARTIUM

Branch or stem not noticeably swollen, peridia more or less cylindrical, not confluent.	12. *P. filamentosum.*
Branch or stem with slight fusiform enlargement, peridia subhemispherical, rounded or irregular, sometimes confluent.	
Spores pyriform, finely and closely verrucose.	13. *P. pyriforme.*
Spores ellipsoid or obovate.	
Spores with wall 1.5–2.5 μ thick, moderately verrucose with uniform papillae.	14. *P. Strobi.*

Spores with wall 2.5–4 μ thick, coarsely verrucose with irregular papillae.	15. *P. Comptoniae.*
Branch or stem gradually or abruptly swollen into a gall, peridia more or less tortuous, usually confluent.	16. *P. cerebrum.*

12. PERIDERMIUM FILAMENTOSUM Peck, Bot. Gaz. **7**: 56. 1882

Aecidium filamentosum Farl. Bibl. Index **1**: 44. 1905.

Peridermium stalactiforme Arth. & Kern, Bull. Torrey Club **33**: 419. 1906.

O. Pycnia unknown.

I. Aecia chiefly on branches 6–12 mm. in diameter, not producing noticeable swellings, scattered, solitary, cylindrical or subcompressed, 1–2 mm. in diameter, usually elongated, sometimes up to 6 or 7 mm. high; peridium rupturing laterally, with more or less evident filament-like processes passing through the spore-mass from apex to base of sorus, or when on *Pinus contorta* and its close allies often appearing on larger branches, the sori often irregular, shorter and more nearly hemispherical, the processes extending from the apex and floor of the aecium only a short distance into the spore-mass; aeciospores oblong, obovate-oblong, or ellipsoid, 14–24 x 23–35μ; wall 2.5–4 μ thick, closely and rather coarsely verrucose, some spores showing a smooth area on one side toward the base.

On *Pinus ponderosa* Dougl., Arizona (*Pringle*).

On *Pinus scopulorum* (Engelm.) Lemm., Colorado (Monte Vista, 1907, *Hedgcock,* as on "*P. ponderosa*"; near Mancos, June 6, 1911, *Phillips,* Timber & Forest Dis. Sur. no. *9085,* as on "*P. ponderosa*"; Allen's Park, July 5, 1911, *Spangler;* Devil's Head Mountain, *Dakin;* Pikes Peak, June, 1912, *Notestein,* as on "*P. ponderosa*," used for successful cultures on *Castilleja* by *Hedgcock,* see Phytopath. **2**: 176. 1912).

On *Pinus contorta* Dougl., California (*Long*), Oregon (*Meinecke,* Fort Klamath, May 23, 1912, used for successful cultures on *Castilleja* by the collector).

On *Pinus Jeffreyi* Oreg. Com., Nevada (*Baker 1351*).

On *Pinus Murrayana* Oreg. Com., Washington (*Suksdorf 645,* type of *P. stalactiforme*).

Type collected in Arizona, "on living branches of *Pinus ponderosa,* July, *Pringle*" (the type specimen in the N. Y. State Museum which we have seen, bears the additional data, Santa Rita Mts., July 13, 1881, *Pringle* no. *32*).

DISTRIBUTION: The Rocky mountains from their eastern limits in Colorado to the eastern slopes of the Coast Range, and north and south from the Canadian to the Mexican boundaries. The telial stage on *Castilleja* is now known from nearly the same range.

This rust, as here represented, consists of two forms somewhat unlike in gross characters and hosts, but agreeing well in microscopical characters and apparently in telial relations. The form listed above on *Pinus ponderosa* is the one on which Peck's name *filamentosum* was based. This form is especially characterized by elongated cylindrical sori and by the presence of longitudinal filaments within the peridium. The specimens on *Pinus scopulorum,* a close ally of *P. ponderosa,* while not possessed of the typical characters in so striking a manner as the original seem to belong here. The fact that none of these specimens seem typical may be due to their state of preservation, all of them being considerably weathered, whereas the original specimen on *P. ponderosa* was collected and preserved in prime condition. It was with one of these semi-typical forms that Hedgcock reports successful cultures on *Castilleja.*

The form on *Pinus contorta* and its two close allies agrees in making noticeable swellings of the branches and in microscopical characters but it differs in having shorter, more nearly hemispherical sori, which are sometimes irregular in outline. It is with material of this sort that Meinecke reports cultures on *Castilleja.* The apparent difference between this *Peridermium* and the one used by Hedgcock in his cultures on *Castilleja* has led the latter to assume (Phytopath. 2: 176–7) that two entirely independent species exist. Our examination of a number of specimens of *Cronartium* on *Castilleja* in both uredinial and telial stages from all parts of the geographical range has failed to indicate any morphological variations and this has led us to the opinion that we may possibly be dealing with two *Peridermium* races, with certain structural differences, which have the same telial connection. We have, therefore, ventured to place the *Pinus contorta* forms, to which the name *Per. stalactiforme* belongs, under *Per. filamentosum* although it is done with some doubt. Further cultures are needed before any final conclusion can be reached. We are indebted to Messrs. Hedgcock and Meinecke for furnishing for our studies portions of their authentic material.

The structural differences between these two forms, which are partly one of length of the peridium, may not be so essential as might appear at first thought. Ordinary aecia, which usually appear short and cupulate, oftentimes have been known to grow out into a cylindrical shape many times as long as broad. The presence of the distinct filaments seems very remarkable in Peck's type and has never been duplicated in any specimens examined by us although the attenuate projections from floor and dome of the aecium as previously pointed out under *Per. stalactiforme* are homologous. It may be possible that none of the specimens listed under this species, except the type, should be referred to *Per. filamentosum* and that this name should be retained for specimens which bear its characters in an unmistakable manner. An argument against such a disposition, however, is the fact that there is no known species of *Cronartium* which might be a telial connection, in other words, if we keep these two forms separate we have more forms of *Peridermium* than are required to account for the known telial stages.

13. PERIDERMIUM PYRIFORME Peck, Bull. Torrey Club **6**: 13. 1875

Aecidium pyriforme Peck, Farl. Bibl. Index **1**: 78. 1905.
Peridermium Betheli Hedg. & Long, Phytopath. **3**: 251. 1913.

O. Pycnia unknown.

I. Aecia appearing on the branches or often on the trunks, with no or only slight fusiform enlargements, scattered and usually distinct, oval or irregular in outline, sometimes elongate, 1–3 by 1–6 mm. or larger by becoming confluent, peridium not much exserted above the roughened bark, rupturing along the sides and falling away; aeciospores pyriform, oblong-pyriform, or obovate, 19–24 x 32–66 μ, usually acuminate below; wall 2–3 μ thick, rather finely and closely verrucose with low papillae; contents orange-yellow when fresh.

On *Pinus Banksiana* Lamb. (*P. divaricata* Auct.), Wisconsin (Douglas County, July 1907, *Davis*).

On *Pinus Murrayana* Oreg. Com., Colorado (Gatos, July 23, 1906, three miles north of Allen's Park, June 21, 1913, *Bethel*); Alberta (Devil's Lake, Banff, July 5, 1907, *Holway*).

On *Pinus ponderosa* Dougl., British Columbia (*Vernon*, May, 1913, *Brittain*, communicated by *Fraser*).

On *Pinus pungens* Lamb., Pennsylvania (Charter Oak, June 2, 1913, *Orton* & *Adams*).

On *Pinus scopulorum* (Engelm.) Lemm., Colorado (three miles north of Allen's Park, June 21, 1913, *Bethel;* South Dakota (Rockerville, June 1909, *White*).

On *Pinus* spp., New Jersey (Newfield, *Ellis 2040*); Washington (Seattle, 1906, *Bonser 65*).

The type specimen in the State Museum, Albany, N. Y., is labeled "on pine limbs in the spring, Newfield, New Jersey, *J. B. Ellis*, no. *2040*." In the original publication it states that Mr. Ellis says that the specimen may have been collected in Georgia and placed by accident among the New Jersey specimens, but it is in the original wrapper and there is strong circumstantial evidence that the inscription on the type specimen is correct.

DISTRIBUTION: New Jersey to Colorado and Washington, northward into western Canada. The probable telial stage on *Comandra* has a slightly wider range, extending into eastern Canada, and into California.

The study of some fresh specimens which have very recently (summer, 1913), come into our hands, together with some data accumulated since our previous paper, has resulted in a complete change of opinion regarding the standing of this species, *Per. pyriforme*. In his original description Peck laid emphasis on the form of the spores which he described as "obovate, pyriform, or oblong-pyriform, acuminate below, .0015–.0025 inch long." We had seen the type specimen, which consists of a portion of a branch a little more than a centimetre in diameter and about 4 cm. long, but we had no opportunity to make a microscopic examination of the spores. Never having seen a *Peridermium* with spores such as Peck described, it was only natural that we should assume that there was something wrong about Peck's description. Knowing that peridial cells are sometimes pyriform we came to the conclusion that he probably mistook some of the smaller peridial cells for spores. With this for an explanation it was possible for us to make his name *pyriforme* apply to a similar looking species common in that range which had ordinary, small, ellipsoid spores. The species to which we made his name apply was the one which has since been culturally connected with *Cronartium Comptoniae.*

Recently when a fresh specimen, collected in British Columbia and communicated to us by W. P. Fraser, with an apparent abundance of spores dropping off in heaps of orange-yellow powder, was examined, we were surprised to find in the first mount only large pyriform bodies. An attempt to regard them as peridial cells not only seemed futile from the first, but was soon rendered impossible by the finding of unmistakable peridial tissue composed of very different cells. An undetermined specimen on a branch of *Pinus Banksiana* collected in Wisconsin in 1907 by J. J. Davis was next thought of. This is an old weathered specimen without any visible sign of peridia but it was remembered that an examination had showed pyriform cells very like the fresh ones then being studied. In both these specimens these pyriform cells had a low verrucose sculpturing very unlike peridial cells, and since their shape and size agreed precisely with Peck's original description the belief that we were dealing here with a characteristic and practically unknown species, except for the obscure type, was gradually forced upon us. Fortunately within a few days some fresh specimens received from Colorado collected by E. Bethel added to our supply of this striking species. These developments gave impetus to the study and we next turned to the herbarium to see if any specimens belonging here might have been placed erroneously, and carelessly, in some other species. Our suspicions were well founded, and we were soon able to add South Dakota, Washington, and Alberta to our list of localities. We were soon able to secure spores from the type specimen in the Museum at Albany, N. Y., which abundantly confirmed Peck's original description, and our recent inferences.

The next problem to present itself was very naturally the question of an alternate phase. According to our new conception we had a *Peridermium* species distributed across the continent from New Jersey to British Columbia with enough intermediate localities to make the distribution continuous throughout the range.

The deduction was soon made that *Cronartium Comandrae* is the probable connection, inasmuch as it is an unassociated form with nearly an identical geographical distribution, *i. e.*, northern United States and southern Canada from ocean to ocean. The fact that it is the only unattached *Cronartium* now known would be enough to strongly suggest the relation, but the complete coincidence of range is a prominent factor in support of the theory. A further bit of evidence is furnished by the field observations of E. W. D. Holway who stated on the packet of his Alberta collection that it was undoubtedly associated with a *Cronartium* on *Comandra.*

Collectors in the eastern states, especially, should be on the lookout for this interesting species. Although apparently very meagerly represented in herbaria from this region it doubtless occurs not infrequently, judging from the numerous collections of the *Cronartium* on *Comandra.*

14. PERIDERMIUM STROBI Kleb. Abh. Nat. Ver. Bremen **10**: 153. 1887

O. Pycnia scattered, honey-yellow, forming minute bladdery swellings; pycniospores hyaline, ovoid or elliptical, 2–4 μ across.

I. Aecia on fusiform swellings of the stem or branches, usually scattered and solitary, rounded or somewhat elongate, 1–1.5 by 2–5 mm., subhemispherical, 1–2 mm. high, rupturing irregularly along the sides; aeciospores broadly ellipsoid or obovoid, 18–24 x 22–27 μ; wall 1.5–2.5 μ thick, moderately verrucose with low uniform papillae, with a smooth area apparent on some spores at the base often extending up one side.

On *Pinus Strobus* L. Introduced from Europe, through nursery stock, into the northeastern Unitel States and Indiana, Ohio, and Ontario, Canada, in 1909 according to Spaulding, Bull. Bur. Pl. Ind. no. 206, 1911.

Type collected in Bürgerpark, Bremen, Germany, on the bark of *Pinus Strobus.* It was first observed in 1886 but the information in the original publication is not definite enough to permit the designation of any particular collection as type.

DISTRIBUTION: Locally introduced with nursery stock from Maryland and Vermont to Illinois and Wisconsin, but believed to have been destroyed in every case; common in Europe.

The rust here described under the name *Per. Strobi* is the one which has come to be generally known as "the blister rust of white pine," and has been connected by numerous cultures in Europe and America with the *Cronartium* on *Ribes*. The presence of the aecial stage (*Per. Strobi*) in North America has been known only since 1909 when it was imported in nursery stock from Germany and widely distributed, especially in the northeastern states. The rust on the *Ribes* has been known for a somewhat longer period. The first record was a collection of the uredinial stage on *Ribes longiflorum* (reported as *R. aureum*) in Kansas in 1892. Definite observations on a sufficient scale to indicate its establishment in this country date back only to 1906 when Stewart found the uredinial stage in the currant plantation of the Experiment Station at Geneva, N. Y. Since that time it has been reported in various localities. There is no information at hand which is of assistance in explaining the early isolated occurrence in Kansas. Through Mr. W. H. Rankin, of Cornell, we learn that recently (spring, 1913), two white pine trees, about fifteen years old, have been found at Geneva with evidence of old infection of the blister rust.[4] One tree is said to show signs of having been infected when very young and long cankers, almost girdling the trunk, have spread upward from the lower whorl of branches, where infection took place, a distance of about three feet. The fungus was fruiting in abundance this spring (1913) on the newly invaded tissue at the edge of the cankers. The fact that this must have been fruiting several years ago will assist in accounting for the original epidemic at Geneva, as well as for more recent outbreaks there.

The condition which obtains in North America with regard to this species is a peculiar one. The white pine, a native only of this continent, was not originally afflicted with a rust disease but upon being extensively grown from seeds in European nurseries it became subject to this extremely damaging species which was later imported to its native country by nursery stock. It is so serious in some parts of Europe that the culture of the white pine has had to be abandoned. The same condition will doubtless be reached in this country if every precaution is not taken to stamp out the disease. Recently the rust has been found fully established on large trees of native white pine in northern Vermont. Steps have been taken to extirpate it in this locality. The quarantine regulations of the various states and of the federal government are clearly efforts in the right direction. It may be found necessary eventually to prohibit importation of white pine stock.

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[4] This is mentioned by Spaulding, Phytopath. 4: 4 (1914) in an abstract of a paper entitled "Notes on the white pine blister rust," and also by Stewart and Rankin, Phytopath. 4: 5. 1914.

Since 1909, and possibly earlier, the presence of a *Cronartium* on *Ribes longiflorum* has been known from Colorado through the collections of Mr. E. Bethel. The rust has been especially common in the parks of Denver and Boulder, and has appeared each year in the same spots since the first observation, but does not seem to have spread. Search at different times by Mr. Bethel has failed to reveal any aecial source of the infection. No white pines, or other species of pine which could be suspected of harboring the rust, grow in the immediate vicinity. A careful search was made at the Boulder station in August, 1911, by the writers aided by Mr. Bethel, and again in August, 1912, by the senior writer alone, but no additional evidence could be detected to explain the outbreak.

15. PERIDERMIUM COMPTONIAE (Arthur) Orton & Adams, Phytopath. **4**: 24. 1914

Cronartium Comptoniae Arth. Bull. Torrey Club **33**: 29. 1906.
Peridermium pyriforme [Peck, misapplied by] Arth. & Kern, Bull. Torrey Club **33**: 419. 1906.

O. Pycnia unknown.

I. Aecia chiefly on small branches 0.5–2 cm. in diameter, or on the trunks of small trees 2.5–5 cm. in diameter, producing only slight fusiform enlargements, individual sori rounded or irregular, 1–1.5 by 1–2 mm. across, sometimes larger by becoming confluent, subhemispherical, 1–2 mm. high, rupturing irregularly along the sides; aeciospores ellipsoid or obovate, 16–24 x 24–33 μ; wall 2.5–4 μ thick, rather coarsely verrucose with irregular and somewhat deciduous tubercles, with a smooth area at base often extending up one side.

On *Pinus austriaca* Höss., Connecticut (*Clinton,* see Rep. Conn. Exp. Sta. for 1912, p. 354).

On *Pinus echinata* Mill., North Carolina (*Spaulding,* see Phytopath. 3: 309. 1913); Pennsylvania (Bear Meadows, Center County, May 26, 1913, communicated by *C. R. Orton*).

On *Pinus maritima* Poir, Connecticut (*Clinton,* see Rep. Conn. Exp. Sta. for 1912, p. 354).

On *Pinus montana* Mill., Connecticut (*Clinton,* see Rep. Conn. Exp. Sta. for 1912, p. 354).

On *Pinus ponderosa* Dougl. (cultivated), Massachusetts (Arnold Arboretum, May 28, 1884, specimen in Herb. Farlow); Wisconsin (Trout Lake, June 28, 1913, *Moody,* communicated by *A. G. Johnson*).

On *Pinus rigida* Mill., Connecticut (Storrs, June 4, July 5, 1907, *Thom*); New Jersey (Newfield, May, 1890, *Ellis*); New York (Albany, June 8, 1910, Hudson Falls, June 22, 1911, *Atwood*).

On *Pinus sylvestris* L., Connecticut (Rainbow, Experiment Station forest, June 15, 1907, *Clinton,* used for successful cultures on *Comptonia* by the collector); Missouri (fruticetum Missouri Botanical Garden, St. Louis, May 1887, *Pammel*); New York (Albany, May 19, 1911, in shipment of trees from Massachusetts, *Atwood,* in nursery at Bluff Point, near Plattsburgh, May, 1912, communicated by *Rankin*).

On *Pinus Taeda* L., New Jersey (*Spaulding,* see Phytopath. 3: 309. 1913).

On *Pinus virginiana* Mill (*P. inops* Ait.), New Jersey (*Ellis* in N. Am. Fungi *1021*).

DISTRIBUTION: Massachusetts to North Carolina westward to the Mississippi river from Wisconsin to Missouri, but chiefly eastward.

The species here represented is the one to which we misapplied the name *pyriforme* in our previous paper. In gross appearance it resembles somewhat the genuine *pyriforme* although it is usually on the smaller branches or stems while the latter is more often on larger limbs or trunks. In general appearance and in the habit of attacking the stems of seedlings and small trees this species is perhaps more closely allied to the white pine rust. It differs from that species very materially in microscopic spore characters, having larger, thicker-walled spores, which are verrucose with coarse, irregular, deciduous tubercles, rather than with uniform, permanent tubercles.

In several instances our attention has been called to the damage which this species is doing to seedlings of the Scotch pine in nurseries. The general similarity in appearance and habit has led some observers to suggest that perhaps the Scotch pine and white pine blister rusts might be the same species. In this connection the morphological differences above pointed out are of interest, but of still greater importance is the fact that Clinton has succeeded in culturing the Scotch pine rust on *Comptonia asplenifolia.* The relationship of the pitch pine specimens here listed to *Cronartium Comptoniae* is also unquestionable. With the data obtained from field observations, morphological characters, and infection experiments it seems that we are safe in concluding that the pitch and Scotch pine rusts are the same species and quite distinct from the white pine species.

More recently (June, 1913), specimens have come to hand showing that this species is also causing damage to *Pinus ponderosa* in a nursery in northern Wisconsin. Since the *Cronartium* on *Comptonia* has been collected in the same region the outbreak may be explained. With the exception of this locality and one in the fruticetum of the Missouri Botanical Garden, where an infected tree was doubtless planted, the species seems to be pretty well confined to the eastern United States.

Recently (Phytopath. **3**: 308. Dec. 1913) Spaulding has given an account of the injury which this species of rust has been observed to do among cultivated pines.

16. PERIDERMIUM CEREBRUM Peck, Bull. Buffalo Soc. Nat. Sci. **1**: 68. 1873

Peridermium Harknessii Moore, Bull. Calif. Acad. Sci. **1**: 37. 1884.

Aecidium deformans Mayr, Waldungen Nordam. 119. 1890.

Aecidium giganteum Mayr, Waldungen Nordam. 120. 1890.—Bot. Centr. **58**: 149. 1894.

Peridermium deformans Tubeuf, Pflanzenkr. 429. 1895.

Peridermium giganteum Tubeuf, Pflanzenkr. 429. 1895.

Aecidium cerebrum Dietel, in Engler & Prantl, Pflanzenfam. **1**^{1**}: 79. 1897.

Aecidium Harknessii Dietel, in Engler & Prantl, Pflanzenfam. **1**^{1**}: 79. 1897.

Peridermium fusiforme Arth. & Kern, Bull. Torrey Club **33**: 421. 1906.

Peridermium mexicanum Arth. & Kern, Bull. Torrey Club **33**: 422. 1906.

Peridermium globosum Arth. & Kern, Bull. Torrey Club **33**: 424. 1906.

O. Pycnia indefinitely spread out over the surface of swellings similar to those on which the aecia appear, the overlying cortical tissues with a rather even surface, 40–50 μ high; pycniospores very numerous, globose, 1.5–2 μ.

I. Aecia appearing on globoid swellings 5–25 cm. across, or on fusiform swellings 2–6 cm. by 5–30 cm. long, usually encircling the comparatively small branches, often causing swollen areas only partially encircling the larger branches or main trunks, individual sori elongate or tortuous, sometimes distinct but often confluent so as to appear cerebroid; peridia circumscissile, soon falling away, sometimes in flakes or sheets; aeciospores obovate or ellipsoid, 15–24 x 23–33 μ; wall 2.5–4 μ thick, rather coarsely verrucose, with a smooth area at base often extending up one side.

On *Pinus contorta* Dougl., Alaska (*Trelease 667*).

On *Pinus Banksiana* Lamb. (*P. divaricata* Auct.), Connecticut (communicated by *Clinton*); Michigan (*Wheeler*); Wisconsin (Lone Rock, May 31, 1890, *Goff*, erroneously listed in former paper, Bull. Torrey Club **33**: 424, as on "*Pinus Strobus*," same locality, May 29, 1912, *Davis*).

On *Pinus echinata* Mill. (*P. mitis* Michx.), Arkansas (*Bethel, von Schrenk*).

On *Pinus radiata* Don. (*P. insignis* Dougl.), California (*Blasdale, Fawcett, Bethel*).

On *Pinus Murrayana* Oreg. Com., California (Yosemite Valley, May 29, 1895, *Blasdale*); Colorado (Bald Mt., Central City, July 4, 1908, Lake Eldora, July 21, 1910, Aug. 5, 1911, June 30, 1912, Silver Plume, Dec. 24, 1906, Tolland, July 30, 1906, Aug. 15, 1906 in Barth, Fungi Columb. *2243*, all by *Bethel;* Tolland, May 18, 1908, *Kern;* Long's Peak Inn, Estes Park, Aug. 7, 1908, *Clements*); Montana (Libbey, Oct. 15, 1911, *Wier 37*); the Colorado and Montana specimens are included here on morphological grounds although some doubt is thrown upon this disposition by the failure up to this time to find the alternate stage within this geographical range.

On *Pinus oöcarpa* Schiede, Jalisco (*Pringle*).

On *Pinus palustris* Mill., Florida (*Rolfs*), Texas (*Spaulding*).

On *Pinus patula* Schiede & Deppe, Hidalgo (*Pringle*).

On *Pinus ponderosa* Dougl.?, British Columbia (Communicated by *Fraser,* 1912), Washington (*von Schrenk*).

On *Pinus rigida* Mill., New Jersey (*Ellis,* in N. Am. Fungi *1022, Shear 1456*); New York (*Lintner*); Ohio (*Kellerman*).

On *Pinus sabiniana* Dougl., California (Colfax, *Harkness 28,* Newcastle, Feb., 1906, *Shear,* Placerville, *Fawcett,* Sept., 1913).

On *Pinus scopulorum* (Engelm.) Lemm., Nebraska (Chadron, Aug. 7, 1909, *Weaver;* Long Pine, May 13, 1896, *Bates 370,* as on "*Pinus ponderosa*").

On *Pinus Taeda* L., Alabama (Auburn, *Earle,* no date, April 1896, *Underwood,* type of *Per. fusiforme* Arth. & Kern, April 6, 1912, *Arthur* & *Kern,* April 7, *Arthur, Lloyd,* & *Kern,* March 22 and April, 1913, *Wolf,* the latter two used for successful cultures on *Quercus* by the writers); Florida (Gainesville, Feb. 2, 1906, *Rolfs,* same locality, March 7, 1910, *Burger,* Lake City, Feb. 26, 1909, *Rolfs*); Mississippi (*Tracy*).

On *Pinus virginiana* Mill., Delaware (Seaford, April 24, 1908, *Jackson*); District of Columbia (Washington, May 11, 1903, April 24, 1905, *Shear*); Maryland (Glen Sligo, May 5, 1905, *Ricker;* Takoma Park, May 10, 1906, *Shear,* used for successful cultures on *Quercus* by the senior writer; Takoma Park, April 14, 1907, *Shear;* College Park, Sept. 20, 1910, *Demaree*); North Carolina (Durham, May, 1911, *Wolfe*); Virginia (*Long, Shear*).

On *Pinus* sp., Georgia (*Ravenel, O'Gara*).

Type collected at Centre (now called Karner), New York, on trunks and branches of young pine trees, *Pinus rigida, J. A. Lintner* (the specimen in Herb. Peck bears in addition the date May, but no year is given).

DISTRIBUTION: Nearly throughout the United States, southward to central Mexico; and northward along the mountains to southern Alaska.

This species, as now represented, includes several of the forms which were previously regarded as distinct. The most notable advance in this connection has been the proof by our cultures this season (1913) that the *fusiform* specimens (*Per. fusiforme* A.

& K.), so common in the southern states, have their uredinia and telia on *Quercus*. Perhaps these specimens are sufficiently differentiated so that they might constitute a race but with only the present knowledge of their culture behavior we believe it best simply to include them in the *Cronartium Quercus* species. It is interesting to note that in doing this, after an attempted separation, the pendulum swings back to the original contention of Underwood and Earle (Bull. Torrey Club **23**: 405. 1896), in which they decided that these macroscopic characters should be disregarded, and not be allowed to "serve as specific characters of equal weight with those which require a microscope to detect." They included the fusiform specimens under *Per. cerebrum*. It seems possible that the form of the gall may be dependent to some extent upon the rate of growth taking place in the affected part at the time of infection and for a few months thereafter. The preponderance of the fusiform type of enlargement on *Pinus Taeda* in the south might be due to a more vigorous growth of the host following the infection period than is likely to take place in northern species and localities.

In separating the Wisconsin specimen under the name *Per. globosum* we were influenced to a large extent by supposed identity of the host and to a lesser extent by minor structural characters. The host was given as white pine by a well-known careful collector, but there were no leaves with which to verify the determination. Dr. J. J. Davis has since visited the original locality and finding there only the ordinary *Per. cerebrum* on *Pinus Banksiana* suggested an error with regard to our statement. A portion of the twig was then submitted to Mr. C. T. Humphrey, of the Forest Products Laboratory, University of Wisconsin, who gives it as his opinion that the host cannot be *Pinus Strobus* and that it has all the chief characters of *Pinus Banksiana*. Further microscopic study has also shown us that we laid too much emphasis on the variations noted in the peridial cells. We are, therefore, convinced that the founding of the species was unwarranted. Essentially the same condition holds for *Per. mexicanum* which is also now included under *Per. cerebrum*. With regard to this form we were influenced by slight structural variations and also by the geographical location. The subsequent knowledge that the *Cronartium* on *Quercus* occurs also in southern Mexico has greatly assisted us in coming to the present conclusion.

Considerable advance has been made also in the knowledge of the development of the aecial stage. With the aid of Dr. C. L. Shear the existence of the pycnial stage has been demonstrated, and a brief technical description has been included in the above diagnosis. Dr. Shear also points out that the fungus seems to have a biennial development, at least he is sure in some cases that only pycnia develop the first season following infection. Two years would thus be required for the development of the aecia.

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